Pusher Syndrome in stroke patients. The current state of knowledge on assessment and physiotherapy

Patologiczne odpychanie u chorych po udarze mózgu. Aktualny stan wiedzy na temat badania i metod fizjoterapii

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Key words
Pusher syndrome, physiotherapy, pusher behaviour

Abstract
Introduction: Pusher Syndrome is a result of damage to the central nervous system manifesting itself as a postural disturbance, whereby the patient in every position pushes himself away in the direction of the paresis and actively resists any attempts towards passive correction of posture. Such behaviour results in the body being position being established according to its own distorted sense of verticality.
Aim: The review of literature dedicated to the symptoms, research and physiotherapy conducted within pusher syndrome.
Methods: A review of studies published within the following electronic databases: Scopus, Embase, Pubmed/Medline, PeDro, Cochrane, ProQuest for the period from 01.01.2002 to 13.09.2013.
Results: Results of research and publications on the subject of Pusher Syndrome appear only occasionally. The subjects of such research are: examination methods, searching for neurophysiological explanations of the Pusher Syndrome and its concurrence with other neurological disorders. Physiotherapy with clear practical implications is rarely the subject of research. The state of knowledge on the matter of the effectiveness of physiotherapy in Pusher Syndrome is based chiefly on narrative reviews as well as on case study reports. Their analysis points to an approach to be adopted as regards the rehabilitation of this group of patients which is based on the principle of motor learning with the use of visual cues as well as proceedings blocking the possibility to push away with limbs that are indirectly involved (limbs on the opposite side to the paresis are referred to as directly involved) in all positions the patient assumes.
Conclusions: There is limited literature available regarding physiotherapy methods used in PS. Existing knowledge is primarily based on observational studies and case reports which provide low evidence (grade III) for clinical practice. The analysis of 9 publications with high risk of bias showed that physiotherapists apply: positioning, principles of motor learning, using visual cues, galvanic vestibular stimulation, robot assisted gait therapy and methods of preventing the possibility for a pushing away with indirectly involved limbs. Most of the included studies promote the same scheme of treatment approach for patients with PS, described in four main points (A-D) in section *Physiotherapy treatment* of the article.

Słowa kluczowe
patologiczne odpychanie, fizjoterapia

Streszczenie
Wprowadzenie: Patologiczne odpychanie to zaburzenie posturalne pojawiające się przy uszkodzeniach centralnego układu nerwowego, w którym chory odpycha się we wszystkich pozycjach w kierunku strony niedowładnej oraz aktywnie oporuje każdą próbę pasywnej korekcji postawy. Zachowanie takie prowadzi do ustawiania ciała według własnego, zaburzonego poczucia pionu.
Cel: Przedstawienie aktualnych, wiarygodnych doniesień z przeglądu piśmiennictwa naukowego, na temat: objawów, badania i fizjoterapii patologicznym odpychaniu.

The individual division on this paper was as follows: A – research work project; B – data collection; C – statistical analysis; D – data interpretation; E – manuscript compilation; F – publication search

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Metody: Przegląd piśmiennictwa zamieszczonego w elektronicznych bazach danych: Scopus, Embase, Pubmed/Medline, PeDro, Cochrane, ProQuest obejmujący okres od 1.01.2002 do 13.09.2013.
Wyniki: Wyniki badań i publikacje na temat patologicznego odpychania ukazują się sporadycznie. Ich przedmiotem są: sposoby badania, poszukiwanie wyjaśnień neurofizjologicznych patologicznego odpychania oraz jego współwystępowanie z innymi zaburzeniami neurologicznymi. Rzadko przedmiotem publikacji jest fizjoterapia o wyraźnych implikacjach praktycznych. Stan wiedzy na temat skuteczności fizjoterapii w patologicznym odpychaniu bazuje głównie na doniesieniach narracyjnych (ang. *narrative review*) oraz opisach przypadków (ang. *case report*). Ich analiza wskazuje na podejście do usprawniania tej grupy chorych oparte o zasady nauczania motorycznego z wykorzystywaniem wskazówek wzrokowych oraz postępowanie uniemożliwiające odpychanie się kończynami *pośrednio zajętymi* (po stronie przeciwnej do kończyn niedowładnych nazywanych *bezpośrednio zajętymi*) we wszystkich pozycjach, w których znajduje się pacjent.
Wnioski: Zagadnienia z zakresu sposobów badania i metod fizjoterapii w patologicznym odpychaniu wymagają bardziej rzetelnych badań klinicznych, głównie randomizowanych, z grupą kontrolną oraz usystematyzowania dotychczasowej wiedzy i zdobytego doświadczenia pod kątem praktycznego zastosowania klinicznego.

INTRODUCTION

In 1985 Path Davis[1] first described pusher behaviour in stroke patients. This was an atypical behaviour of actively pushing weight with *indirectly affected* extremities, which not only resulted in falls on the *directly affected* side but also substantially delayed the ability to obtain a vertical position in these patients. This finding marked the beginning of ongoing scientific research concerning the sense of vertical posture and brain structures participating in receiving and interpreting information about this posture and its consequences, as well as treatment of various disorders of these systems[2,3]. In many areas scientists agree with each other; however, many of the issues, due to a high degree of complexity, still raise considerable controversy. To evaluate the importance of individual reports, especially those which bring conclusions essential for practice, it is worth paying attention to the reliability of clinical trials. The purpose of the present article is to present the current state of knowledge on Pusher Syndrome, (PS), with particular emphasis on physiotherapy, based on a critical review of the thematic literature, including the assessment of the reliability of individual trials.

METHODS

In order to present the current state of knowledge on pathological pusher behaviour, a review of the literature published in the period from 1.01.2002 to 13.09.2013 with the use of subject headings: „*pusher syndrome*" and „*pusher behaviour*", has been performed. The following electronic databases have been searched: Scopus, Embase, Pubmed/Medline, PeDro, Cochrane, ProQuest. Out of the 130 titles obtained, having removed the repetitions, 76 were obtained and on these, after the exclusion of the letters to editor and after evaluation of articles according to their titles, abstracts and full texts, a narration review was performed. Due to lack of randomized control studies, the importance of the reports was evaluated based on their methodology[4]. When constructing the review, a typical hierarchy of reliability of reports was adopted:

- A meta-analysis of randomized controlled trials;
- Individual randomized trial;
- Non-randomized experimental trial with a control group;
- Systematic review of observational studies;
- Single observational trial;
- Case reports or series of case reports.

PUSHER SYNDROME

Physiological sense of verticality

Physiologically, the perception of body orientation with regard to the vertical is possible due to convergence (connection) of signals from various sources including: the vestibular, visual and somatosensory system[5,6]. Researchers have identified three basic sensory channels the correct performance of which guarantees obtaining the necessary information involved, and their integration allows for a correct sense of verticality (Table 1). One of the three elements is the visual perception of verticality, the visual vertical (VV) based on the vestibulo-ocular information[2]. The next source of information is the postural perception of body vertical, the postural vertical, (PV) based on information from sensory organs, including the organ of balance in the inner ear[7,8,9]. Another source of information is the peripheral sensation, through which it is possible to define the so-called haptic vertical (HV)[10,11]. Damage to any of the components of the gravitational vertical perception leads to a variety of posture and balance control disorders, which also include pathological pusher behaviour[14].

Definition and physiopathology

Currently, pusher behaviour is defined as a postural disorder in which patients push their weight to the paretic side in all positions and actively withstand any attempt of passive correction of the posture [14]. In other words, the patients will oppose any attempts of shifting them towards the median line of the body or further, towards the nonparetic, or the *unaffected side*[15]. It is not difficult to imagine that this disorder leads to the loss of postural balance and to a tendency to fall to the affected side. Attempts at explaining the reasons for such behaviour continue to this day[2,14,16]. Karnath et al.[15] have demonstrated that patients with pusher behaviour 'report' subjective postural upright at the time of an 18 degree tilt, on the average, towards the indirectly *affected side*. However, when they were allowed to use visual guidance, their position did not deviate from normal. In view of such results, researchers still wondered why patients push their weight

towards the *directly affected side*, since subjective postural vertical (SPV) is shifted in the opposite direction, and the subjective visual vertical (SVV) is working properly. It has been presumed that there is an impaired internal representation of the body, tilted relative to the vertical, and that the observed motor behaviour of patients is an attempt at compensating for conflicting information on the gravitational vertical coming from various sensory centres[11,15,17]. Further research in this area challenged the earlier cited results, as Pérennou observed that the displacement of the sense of postural and sensory line of gravity is always towards the *directly affected* side in cerebral hemisphere stroke patients[2]. In the author's opinion, the asymmetric position of the patient's body resulted from impaired sense of the body vertical and an attempt at setting the position of the body according to perceived body vertical. From among the 80 patients observed, 34 demonstrated an impaired postural vertical, 44 - impaired vertical eye, and 26 - impaired tactile body vertical, always in the direction opposite to the affected hemisphere. It is worth mentioning that slightly more than half of the patients had a disorder of at least one modality, and nearly ¼ of the patients - of all three modalities. Researchers have also noticed that the vertical postural deviation was more often associated with a disorder of posture than the vertical eye deviation, and pathological Pusher Syndrome occurred in patients with biggest vertical postural deviations. Moreover, all patients with an impairment of all three centers of graviperception had the most severe symptoms of lateropulsion and pathological Pusher Syndrome. In view of these results, researchers hypothesized, that pathological Pusher Syndrome is a motor behaviour, leading patients to set their body in accordance with their own, disturbed sense of the vertical[2].

There is also an ongoing research on which centers of the brain are responsible for the impaired sense of vertical. There is general agreement as regards the meaning of the right hemisphere, especially the area of the primary somatosensory cortex and thalamus. According to the researchers, thalamo-cortical projection is responsible for processing information on the vertical position relative to the ground[2]. The crucial role of the right hemisphere in developing an internal model of body position relative to the vertical and controlling the orientation of the body in relation to the force of gravity is also stressed. In 2005, the studies of Lafosse et al.[18] also confirmed this, when having studied 114 stroke patients, they demonstrated the correlation of the presence and severity of Pusher Syndrome with the location of brain damage and the coexistence of hemispatial neglect. At the time of admission to the rehabilitation unit, the frequency of symptom occurrence did not differ significantly between patients with right and left hemisphere damage (respectively 52% and 40%), whereas 12 weeks later the symptom occurred more frequently in patients with right hemisphere damage (50% vs. 20%). Given the prevalence of this symptom in stroke patients, which varies between 10% and 63%, an accurate diagnosis, assessment of symptom severity and appropriate rehabilitation treatment seem to be crucial for the proper conduct of the treatment process in patients with Pusher Syndrome[20,21], especially with relatively numerous and often conflicting opinions of authors[14,20,21].

Table 1

Testing of the components of the graviception system (the sense of the gravitational perpendicular) according to Pérenou[2]

Graviception component	Patient	Task	Physiological error limit
V*isual vertical* (VV)	Seated in a dark room, in a chair installed on a round drum-like construction allowing for its rotation in the frontal plane. The seated patient can be tilted to the left or to the right. The patient's feet are above the ground, the thorax, head and extremities are stabilized, preventing movements of parts of the body in relation to each other. Eyes open.	Vertical position of a highlighted line visible in a screen, displayed in front of the patient. Highlighted line initially tilted randomly to the left or right, the screen contours covered up to prevent the patient referring the direction of the line to the straight line defining the edge of the screen. Using verbal commands, the patient informs the investigator in which direction to tilt the observed line. 10 tests are performed.	2,5 degrees
***Postural vertical*, (PV)**	As mentioned above, but eyes closed and blindfolded.	Signaling by the patient at the moment of having felt the body vertical. At the beginning of the test, the patient's body is tilted 15-45 degrees to the left or right. The operator moves the construction slowly in the opposite direction to the initial tilt. Low speed of drum rotation and stable head position in relation to thorax allow for a selective otolitic stimulation. 10 tests are performed. 5 tests in each direction.	2,5 degrees
H*aptic vertical*, (HV)	Patient in the same position with closed eyes. Shoulders and thorax in this test are not stabilized, this makes it possible to manipulate a stick located 40-50 cm in front of the patient.	Setting a stick vertically which is mounted on a base and randomly swung to the left or to the right. The patient performs 10 tests.	4,5 degrees

Study

We encounter the first doubts already with the scales for evaluating pathological Pusher Syndrome. One of the most frequently used measurement tools in clinical research published in Rehabilitation Medicine in 2004[22] is the Scale for Contraversive Pushing, (SCP)[23,24]. It assesses three aspects: spontaneously adopting a posture, pushing with unaffected extremities, and the behaviour during an attempt at passive correction of the improper posture. These components are evaluated in the sitting and standing position. To confirm the diagnosis, the accumulated value assessed in sitting and standing positions should be at least 1 point (maximum value is 2). Some authors have confirmed PS in patients whose total score reached a value other than zero[20]. Research on the validity and reliability of measurements performed by other researchers positively verified the value of the discussed scale[24]. Doubts were raised, however, concerning the compatibility of the results of the scale with the actual clinical diagnosis, whereby a significant number of false negative diagnoses was noticed[25]. The SCP scale proved to be particularly unreliable in patients with discrete symptoms appearing only during dynamic activities, such as walking. Therefore, Baccini et al.[26] suggested that the diagnosis of pathological Pusher Syndrome be confirmed with the result already different from 0 achieved in the individual sections of the scale. In 2006 Swedish researchers Lagerqvist and Skargren[27] published the Modified Scale for Contraversive Pushing, (M-SCP) which differed significantly from the previous one and consisted of 4 parts, each of them assessing the patient during their functional activities such as: 1. static sitting, 2. static standing, 3. changing the position from sitting, 4. changing the position when standing or changing the direction of gait. Each part of the scale is assessed separately within the range from 0-2 points, where zero means no symptom, and 2 its most severe form. The authors suggest that pathological Pusher Syndrome should be confirmed with the result of a total of > 3 points[27]. Studies have confirmed satisfactory accuracy and sensitivity of the scale and high compatibility of measurements between researchers. However, the authors did not compare the new tool with the previously discussed pathological Pusher Syndrome classification scale (SCP).

Another tool for pathological Pusher Syndrome assessment is a 17 score scale, the Burke L**ateropulsion Scale**, (LS)[28]. It was published and validated in 2004. It has a high level of measurement reliability between researchers, and of repeated measurements of the same researcher [respectively inter-rater (r=0.93) and intra-rater (r=0.94)]. It assesses the severity of pathological contraversive pushing in the following activities: turnover lying down, sitting, standing, posture changes and walking. According to Paci et al.[21] the use of LS scale requires a relatively long time to complete, and reading the research procedure is too time-consuming.

In the systematic review Babyar et al.[24] conclude that the scale of pathological contraversive pushing (SCP) is the most common and best tested tool for assessing this symptom and perhaps it therefore has the best clinimetric qualities. Two other scales, the Modified Scale for Contraversive Pushing(M-SCP) and the Lateropulsive scale Burke (LS) assess the patient in more functional positions, and their reliability and validity allow for the use of both tools for research and for clinical decision-making[24]. The most recent studies by Krewer et al.[29] from 2013, however, show greater sensitivity of the lateropulsive scale, where changes in intensity of the pathological contraversive pushing were observed after only one treatment session, the fact which the SCP scale did not register. According to the authors, this result is associated with a wider metric range of LS scale. In deciding whether a stroke patient should be examined for the presence of pathological contraversive pushing, it is helpful to observe the following motor behaviours that may indicate the existence of PS[30]:

- **lying down:**
  - pushing by the nonparetic extre-mity towards the paretic side, consequently resulting in an asymmetrical position of the trunk or of the whole body in bed,
  - efforts to adopt the lying position on their back or on the paretic side,
- **sitting, standing and walking:**
  - tilting to the paretic side or backward which leads to a fall to the side or to the back;
  - tilting the trunk in the frontal or sagittal plane, leading to the loss of the vertical;
  - using the hand or foot of the *indirectly affected* (nonparetic) side (based on its toes) to tilt the trunk;
  - actively pushing weight on the paretic side, carried out with great force while being supported, or during the correction of posture performed by the therapist (pushing weight with the paretic side on the body of the supporting therapist);
  - no fear of falling, even with a strong tilt of the trunk to the side (towards the paretic side) or backwards; fear and resistance during an attempt of correcting posture to neutral;
  - in standing position, pushing from stable objects with the nonparetic side, such as: the table, flat surfaces, handrails;
  - when learning to walk no support, pressure or weight transfer on aids such as: canes, tripods or elbow crutches.

Prognosis

Similarly, as in the case of measuring tools, there is also no clear opinion regarding forecasts in patients, diagnosed with pathological pusher behaviour. Studies of Karnath et al.[16] indicate complete relief of symptoms within 6 months of stroke. This result, however, should be interpreted with caution, because as many as 12 of the 23 patients presenting the most severe symptoms during the acute phase have not been assessed in the final measurement. The study results of Danells et al.[20], who say that more than 60% of patients with known pathological contraversive pushing a week after stroke did not have the symptoms already six weeks later, may also be discussed. In only 21% of patients, the Pusher Syndrome re-

mained for three months. As mentioned earlier, Danells et al.[20] classified patients as having a symptom when the total score of the pathological pushing scale SCP was different than 0 points, which is not consistent with the commonly accepted threshold value. In other studies Lafosse et al.[18] confirmed however that within 12 weeks of the end of rehabilitation, pathological contraversive pushing persisted mainly in patients with right hemisphere damage, which is consistent with the earlier published study results on the location of centers involved in processing and obtaining information about the position of the vertical. Despite the above mentioned issues related to prognosis in pathological contraversive pushing, most authors confirm that the process of recovery and regaining the functional fitness in this group of patients is slower and requires longer hospitalization than in stroke patients without pathological contraversive pushing[20,31].

Physiotherapy treatment

Generally, rehabilitation begins in neurological departments or in post-stroke specialist wards. In patients with hemiparesis several methods of physiotherapy are used, based on concepts such as: motor learning[32]; proprioceptive neuromuscular facilitation, (PNF)[33], Bobath[33-35]. In recent years the Constraint-Induced Movement Therapy (CIT)[36] became popular as well as the use of various forms of rehabilitation based on individual and group work, both hands-on and hands-off finally, using a variety of devices and robots (mirror therapy, virtual reality)[37,38].

Based on the reports of Karnath et al.[15] regarding the lack of vertical eye disorders in patients with pathological contraversive pushing, it has been suggested that physiotherapy be based mainly on visual aids[15,39]. In the spirit of this theory, the patient should be taught deliberate postural control strategies in an appropriately structured environment, allowing them the use of visual information as a reference to the course of the vertical[40]. As yet, however, no reports based on controlled clinical trials comparing a therapeutic procedure planned in such a way, with another way of rehabilitation, have been published.

Another concept of physiotherapy was introduced by Bohannon[32], who suggested that principles of motor learning can be used in therapy. The concept is based on a procedure which allows the patient to be aware of an abnormal position of their body in space: while sitting and standing [32]. The patient is allowed to become aware that the posture they adopt and perceive as vertical is not a functional posture for them, as it constantly leads them to a loss of balance and falls. The patient must experience this and having realized this fact, they will reorganize their posture so as to be able to safely maintain a higher position. He may use feedback information given by the physiotherapist and appropriate sensory stimulation. Bohanon argues that the use of visual aid and ordered structure of the therapeutic room is not the only correct strategy in pathological pushing behaviour and the concept of motor learning may prove to be an equally effective approach[32]. However, as in the case of the first one, there are no clinical trials confirming the effectiveness of the proposed strategy.

Panturin[41] demonstrated different principles of physiotherapeutic methods and suggested to improve patients' condition using passive or active movements of the pelvis with a stable thorax. This procedure may in his opinion stimulate receptor groups located in the abdomen, and according to the researchers, precisely these receptors are responsible for SPV[42]. Apart from kinesitherapy, also physical stimuli are used for pathological Pusher Syndrome treatment. Pérennou et al.[2] used percutaneous electrical stimulation of the neck area of the *directly affected* (paretic) side in patients with hemispatial neglect and impaired postural vertical. Volkening and Keller[43] applied ten treatments of left atrial cathode galvanochemical stimulation combined with training based on visual information. As a result of the intervention a significant improvement in patient's perception of the vertical was observed. So far, however, a reliable clinical trial, confirming the effectiveness of that therapy in more patients with PS and its long-term effect, has not been performed. The most recent trial of Krewer et al.[29] in this area of interest seems worth mentioning. It deserves a special mention primarily due to the design of this experimental study. It is the only study evaluating physiotherapy in PS which uses the method of cross-over groups. This means that all the patients, in random order, underwent the same therapeutic procedure, in order to verify which of the three physiotherapeutic methods is the most effective. A significant quantitative difference in the quantity of pathological Pusher Syndrome assessed with the Burke Lateropulsion Scale (LS) was demonstrated with the application of a 20 minute driven–gait orthosis, (DGO) on a treadmill with the use of Lokomat device. Gait training took place with the patient fastened in a special harness supporting 50% of their body weight and placed on a treadmill. Lokomat has been set to completely take control over the lower extremities adequately stabilized in the appliance. Treadmill tape speed was constant and set at 2 km/hour. PS patient physiotherapy led this way proved to be significantly more effective than physical physiotherapy conducted according to the model propagated by Broetz and Karnath, as described below [39]. The conclusions of the cited experimental study should, however, be treated with caution because only 10 patients with PS have been studied, and each of the proposed types of physiotherapy was used only once in a 20 minute session[29].

According to other authors, also the importance of sensory stimulation should not be ignored. Sensory disturbances in PS patients can lead to disorders of various sensory organ information integration, which is necessary in balance control, such as: sight, superficial feeling and vestibular system[18]. They may also disturb the accurate perception and awareness of sensory information, necessary in turn, for planning and performing balance strategies. Current research has shown, however, that sensation is not disturbed more in stroke patients with PS than in those

without pathological Pusher Syndrome, which suggests that somatosensoric information does not play a leading role in body vertical perception and that its disorders are not a direct cause of this symptom[44].

Table 2 shows the reports of the past 10 years, as regards the rehabilitation of pathological Pusher Syndrome.

The above table, particularly the column describing the publication type, shows, that physiotherapy in pathological Pusher Syndrome is mainly based on practical experience. There are no reliable, well-designed clinical trials, carried out on a large sample of patients, which could be referred to when constructing the recommended rehabilitation program for this group of patients. Three of the listed publications are by German neurologists working together at the University of Tuebingen[39,40,45] They present a consistent improvement scheme in pathological Pusher Syndrome, which can be summarized as follows:

A. Making the patient aware of the disturbed position relative to the vertical;
B. Using vertical elements of environment perceived visually to correct body alignment;
C. Teaching movements necessary to achieve correct vertical position;
D. Maintaining the correct vertical position when performing other activities.

The authors emphasize that since pathological Pusher Syndrome is a disorder of body perception relative to the direction of gravity, patients should be rehabilitated in sitting or in standing position[45]. Making the patient aware of the impaired posture relative to the vertical can be achieved by allowing him to lose the balance, and even allowing a controlled fall on the *directly affected* (paretic) side. From this position, the patient is asked to find ways of returning to the vertical posture. One idea is supporting themselves with the *indirectly affected* upper extremity (nonparetic) on the paretic side. If, however, the patient is unable to return to the vertical position, the physical therapist should help him. In order to implement point B, authors recommend the use of visual clues such as vertically extending window frames, jambs, pictures, edges of furniture, or mirrors with indicated mid-line. For this purpose, a physiotherapist may also indicate the vertical line to the patient showing it with a drawn up forearm. The undisturbed perception of the vertical with the visual system does not result in an automatic adoption of the correct body position. The role of the physical therapist is to teach the patient the conscious use of this channel of perception and positioning of the body according to the course of the vertical determined by the surrounding objects. Feedback given by a physiotherapist along with the perception of the patient, who notices that in the corrected vertical position they did not fall, gives them a sense of confidence and reduces the occurrence and severity of the pathological Pusher Syndrome[40,45]. The implementation of the third stage (point C) is realized through tasks given to the patient's *unaffected* (nonparetic) side. They include reaching with their hand to one side for objects which are there: a small ball, bed frame, chair, therapist's hand etc. In this task, the patient cannot use this extremity for contraversive pushing, and with the movement of reaching they shift the body weight on the *unaffected* side (nonparetic). A physical therapist can show the patient the task and with acoustic signals help them locate the target object.

Having trained the first three stages (A, B, C), the patient can proceed to the fourth one (point D). Initially, correct posture alignment is impossible when the patient stops focusing on visual aid and self-posture. Therefore, gradually, confounding factors are introduced which distract the patient's attention from adopted posture, requiring concentration on an additional task. Initially, it may be a conversation or a simple coordination task for the upper extremities or the head. Ultimately, all the therapeutic steps are joined together and trained until the patient is able to maintain a stable vertical and at the same time carry out other activities. A similar rehabilitation scheme is also suggested by Mikołajewska[46]. She stresses the need for positioning the patient symmetrically when lying, and laying them as often as possible on their *unaffected* side (nonparetic). Moreover, in Broetz's study from 2005[39] practical tips on how to move the patient from bed to wheelchair can be found. The authors propose implementing the following tasks to achieve it:

- Teach the patient to tilt their thorax forward (the patient moves his hand over his thighs or their hands to their knees, then to the ankles);
- In the next step the patient is trying to lift up his buttocks and put weight on his feet [supporting oneself on the unaffected extremity (*indirectly affected*) while lifting the thorax];
- If possible, the patient should move one upper extremity to a chair or wheelchair on which he intends to sit;
- The physiotherapist should be standing in front of the patient, grasping the patient from the top near the outer edges of their shoulder. The physiotherapist's knees and feet secure the patient's lower extremities, preventing the abduction of *unaffected* extremity, so that the patient does not use it for contraversive pushing;
- It is recommended to start the change of seating by turning the patient on the paretic lower extremity because the direction of motion is consistent with the direction of a possible push.

Ultimately, the aim is to ensure that the patient is able to transfer in both directions.

Another important practical issue described by Broetz[39] is positioning the patient in a wheelchair. The following guidelines have been presented:

- The patient should sit pushed deep, symmetrically in the middle of the seat;
- A pillow is to be placed between the *affected* shoulder and the wheelchair backrest, which makes it difficult for the patient to lift the buttock on the *indirectly affected* side (associated with contraversive pushing with this lower extremity);
- Upper extremities should lie on the table attached to the wheelchair;
- Feet should be based on the ground;
- It is necessary to notice the strong tendency for contraversive pushing the upper extremities from the ta-

Table 2

Physiotherapy evaluation in Pusher Syndrome

No	First Autohor, year	Type of publication	PS diagnostic tool	Physiotherapy	Duration	Number of subjects
1	Bergmann, [2012][48]	Conference abstract	LS, SCP and SVV assessment, photo documentation before and after each therapy.	Galvanic vestibular stimulation (GVS), robot-assisted gait therapy (RAGT), conventional physiotherapy.	1 week	14
2	Broetz [2005][39]	Narrative review	-	Physiotherapy scheme according to directives described in points: A,B,C,D below the table; method of transfer from bed to wheelchair and positioning in the wheelchair.	-	-
3	Broetz [2004][40]	Case series	MRI and SCP. Assessment in 12., 18. and 24. day after stroke.	Physiotherapy scheme according to directives described in points: A,B,C,D below the table.	26 days of hospitalization (22-35), therapy duration 30 min.; 6 days per week	8
4	Karnath [2003][45]	Narrative review	-	Narrative review about all aspects of PS; Physiotherapy scheme according to directives described in points: A,B,C,D below the table.	-	-
5	Krewer [2013][29]	Experimental study: observer-blinded cross-over	SCP and LS before and after each therapy	Galvanic vestibular stimulation (GVS), gait training with a usage of Driven-gait orthosis (DGO) Lokomoat (trademill speed 2 km/h with body weight support), therapy with visual cues provided to help with finding real vertical.	-	2 groups of patients; 15 subjects with PS and 10 without
6	Mikołajewska [2012][46]	Case study	SCP	Physiotherapy in posterior pusher syndrome: visual cues –vertical elements, in environment; verbal stimulation to help the patient keep upright position thanks to conscious postural control strategy, individualized patient-centered therapy with patients and caregivers education.	2 weeks; 10 treatment sessions.	1
7	Mikołajewska [2011][30]	Overwiew article		Symetrical positioning of patients and physiotherapy scheme according to directives described in points: A,B,C,D below the table; directives about possible intervention in lying, sitting, standing and gait training	-	-
8	Pacci [2004][49]	Case study	SCP, Fugl-Meyer Assessment Scale (FMA), Motor Assessment according to Lindmark (MA), Index Barthel (BI), Modified Ashworth Scale (MAS)	Physiotherapy according to Bobath principles lateral pelvic tilt in sitting; standing with the unaffected arm against a wall or using a table as support, then standing during functional activities using the unaffected upper limb, later learning to stand without a support vocal feedback from the therapist, and visual feedback from a mirror with a drawn midline, use of back support as a table; single leg activities, such as stepping with the affected and unaffected leg forward, and weight-bearing on the paretic and non-paretic leg, striking a ball or using a stair (step position); weight transfer from the unaffected to the affected side and vice versa when sitting; standing up from sitting and transferring from bed to wheelchair; walking with a quad cane and stair climbing.	3 weeks, 27 treatments 2-hours each.	1
9	Stolarski [2010][50]	Case study	Assessment in the first and the last day of therapy with: Orgogonzo Scale, Index Barthel, Scandynavian Stroke Scale. During hospitalization: SCP	Therapy according to PNF concept: trunk stabilization, shoulder girdle stability , reaching activities, verticalization. Active exercises of less-involved extermities, passive exercises of direct-involved extermities with verbal and visual contact, crossing the midline, self-supported exercises of upper limbs.	33 days	1
10	Urquizo, 2009	Expert opinion report	-	PSs as an automatic motor behaviour pattern used as a compensatory strategy to overcome a long period of postural weakness. This chronic muscular hypotone leads to flexion-fixation of the non-affected side, in order to prevent falling to the affected side.Treatment: support patient, give safety in order to modify their position; reorganization of internal representation to improve body scheme; work on stability of the direct-involved side, allow to experience standing position, reorganise space orientation; integration with functional activities (transfer).		

LS – *Lateropulsion Scale*; PS - *Pusher Syndrome*; SCP – *Scale for Contraversive Pushing*; SVV – *Subjective Visual Vertical*

ble in the direction of the paretic side, which causes the buttocks to pull forward towards the *indirectly affected* side. This may cause a slipping of the patient out of the wheelchair, because the table is not a sufficient protection against a fall.

The abovementioned components of rehabilitation of patients with contraversive pushing, based on Paci and Nannetti[47] as well as on Mikołajewska's[46] report, can be supplemented by examples of activity in higher positions:

- Standing with the *indirectly affected* (nonparetic) upper extremity drawn up against the wall, at which the patient is standing (the position of the extremity and the proximity of the wall prevent contraversive pushing) and gait in this position;
- Standing and performing functional tasks with the upper *unaffected* extremity (*indirectly affected*, *nonparetic*);
- Actively ptshing weight on paretic side (*directly affected*) with correction and position control in the mirror;
- Walking in upright position using tables, window sills or other stable elements for support on the nonparetic side, and overcorrection while standing towards the *indirectly affected* (*nonparetic*) side;
- While walking with orthopedic supply or with the help of a physiotherapist, controlling the body posture in relation to the vertical indicated;
- Standing, supported on a table placed behind the patient;
- Activities in standing position on one leg: performing a step or transferring the weight to the lower extremity *indirectly and directly affected*, kicking a ball, climbing a rehabilitation step;
- The transition from sitting to standing, gait using a high stick, crutch or quadruped and walking up stairs.

SUMMARY

1. There is limited literature available regarding physiotherapy methods used in PS. Existing knowledge is primarily based on observational studies and case reports which provide low evidence (grade III) for clinical practice.
2. The analysis of 9 publications with high risk of bias showed that physiotherapists apply: positioning, principles of motor learning, using visual cues, galvanic vestibular stimulation, robot assisted gait therapy and methods of preventing the possibility for a pushing away with indirectly involved limbs.
3. Most of the included studies promote the same scheme of treatment approach for patients with PS, described in four main points (A-D) in section *Physiotherapy treatment* of the article.

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